Search for the decay $B \to D^*\eta\pi$ in Belle II

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Abstract

Recent measurements of semileptonic decays show a difference between the branching ratio of the sum of exclusive decay rates and the inclusive $b \to c\ell\nu$ decay rate (the so-called Semi-Leptonic (SL) gap) which affects the interpretation of the CKM element $|Vcb|$. Large contributions from not-yet measured $B \to D^*\eta\ell\nu$ decays could explain such difference. We present a study of the $B \to D^*\eta\pi$ decay on the simulated data sample of the Belle II experiment. This measurement will provide valuable information to predict its semileptonic counterpart $B \to D^*\eta\ell\nu$. If $B \to D^*\eta\pi$ decay is found to be large, it could contribute significantly to the hadronic B-tagging, and consequently enhance the sensitivity for searching rare B decays with missing energy.

1 Introduction

Approximately 25% of B decays involve semileptonic $b \to c$ transitions, with a significant unexplored region. Our study intends to search the decay $B \to D^*\eta\pi$ for the first time, using Belle II[1] experiment data. The PYTHIA-generated branching fraction for this decay in the Belle II simulation is estimated at 0.34%. The measurement of the decay $B \to D^*\eta\pi$ in Belle II data can provide insight into the Semi-Leptonic (SL)[2] gap problem, impacting the interpretation of the CKM[3, 4] element $|Vcb|$. Moreover, our measurement will offer valuable insights for predicting the semileptonic counterpart $B \to D^*\eta\ell\nu$. If the decay $B \to D^*\eta\pi$ is observed with large sensitivity, it could make a substantial contribution to hadronic B-tagging, thereby boosting the sensitivity in the quest for rare B decays with missing energy.

2 Discussion

We have studied the decay $B \to D^*\eta\pi$ in simulations. We select a kaon and a pion track to form a D-meson, and then a D^* candidate is reconstructed with the D candidate and with a selected π meson. The η-meson candidate is selected in a two-photon final state. Then ultimately a B-meson candidate is reconstructed by combining D^*, η and a pion. The properties of the signal events are studied extensively in a dedicated Monte Carlo simulations (MC) sample containing only signal decays. We also studied another MC sample, containing all the possible events originating from the e+ e- collisions, to understand the background. After applying all the selections, the ΔE ($E^*_B - E^*_{beam}$) distribution in Belle II simulated sample size of **400** fb^{-1} is shown in Figure 1. Unbinned maximum likelihood fit is performed for the distribution ΔE to extract the signal events. The definition of the integrated efficiency (ϵ) involves dividing the number of reconstructed events by the total number of events in the sample (10^6). The signal efficiency obtained by fitting the ΔE distribution is 10%. The branching fraction in the simulated sample was found to be $(3.54 \pm 0.17) \times 10^{-3}$, which is about the same value put in the simulation.

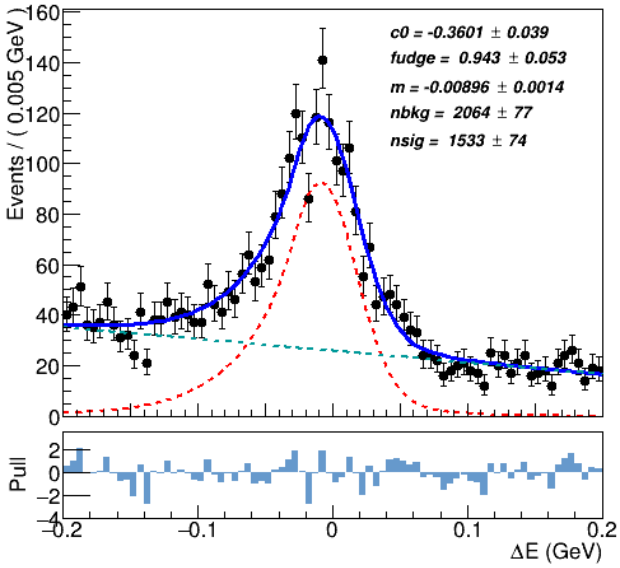

Figure 1: ΔE fit distribution in generic MC.

3 Conclusion

We have studied the decay $B \to D^*\eta\pi$ in Belle II simulations. The calculated branching fraction, after selection and fitting the distribution, is about the same input value in the simulation, which validates our method. We plan to perform the study by using the Belle II data sample in the near future. We anticipate that the branching fraction for this decay observed in the Belle II data will resemble what we observed in our simulation study.

References

1. Abe T. Belle II Technical Design Report. arXiv 2010.
2. Florian U. Bernlochner ZL and Turczyk S. A proposal to solve some puzzles in semileptonic B decays. PHYSICAL REVIEW D 2012.
3. Cabibbo N. Unitary Symmetry and Leptonic Decays. PHYSICAL REVIEW LETTERS 1963.
4. Kobayashi M and Maskawa T. CP-Violation in the Renormalizable Theory of Weak Interaction. Progress of Theoretical Physics 1973.